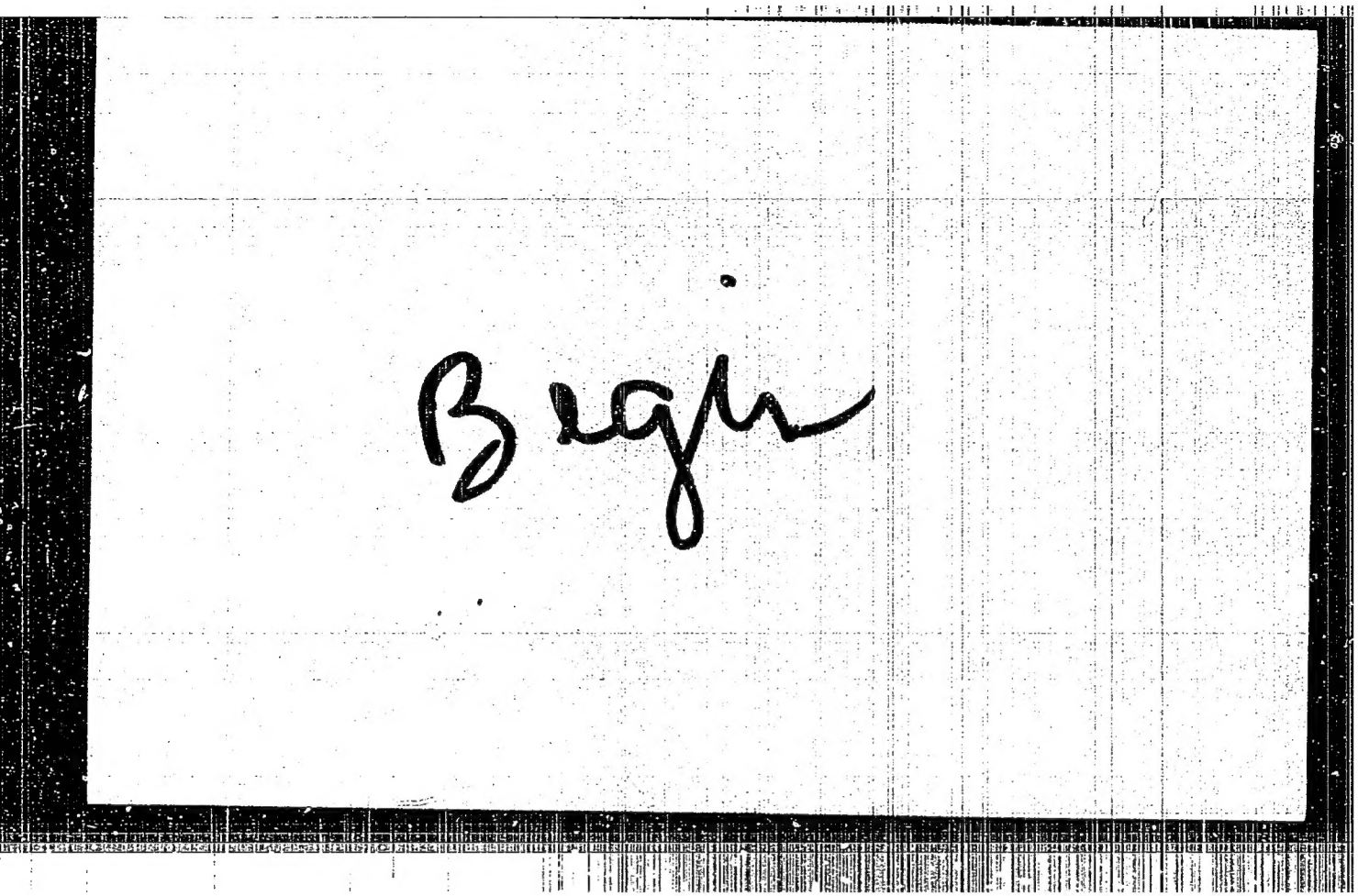
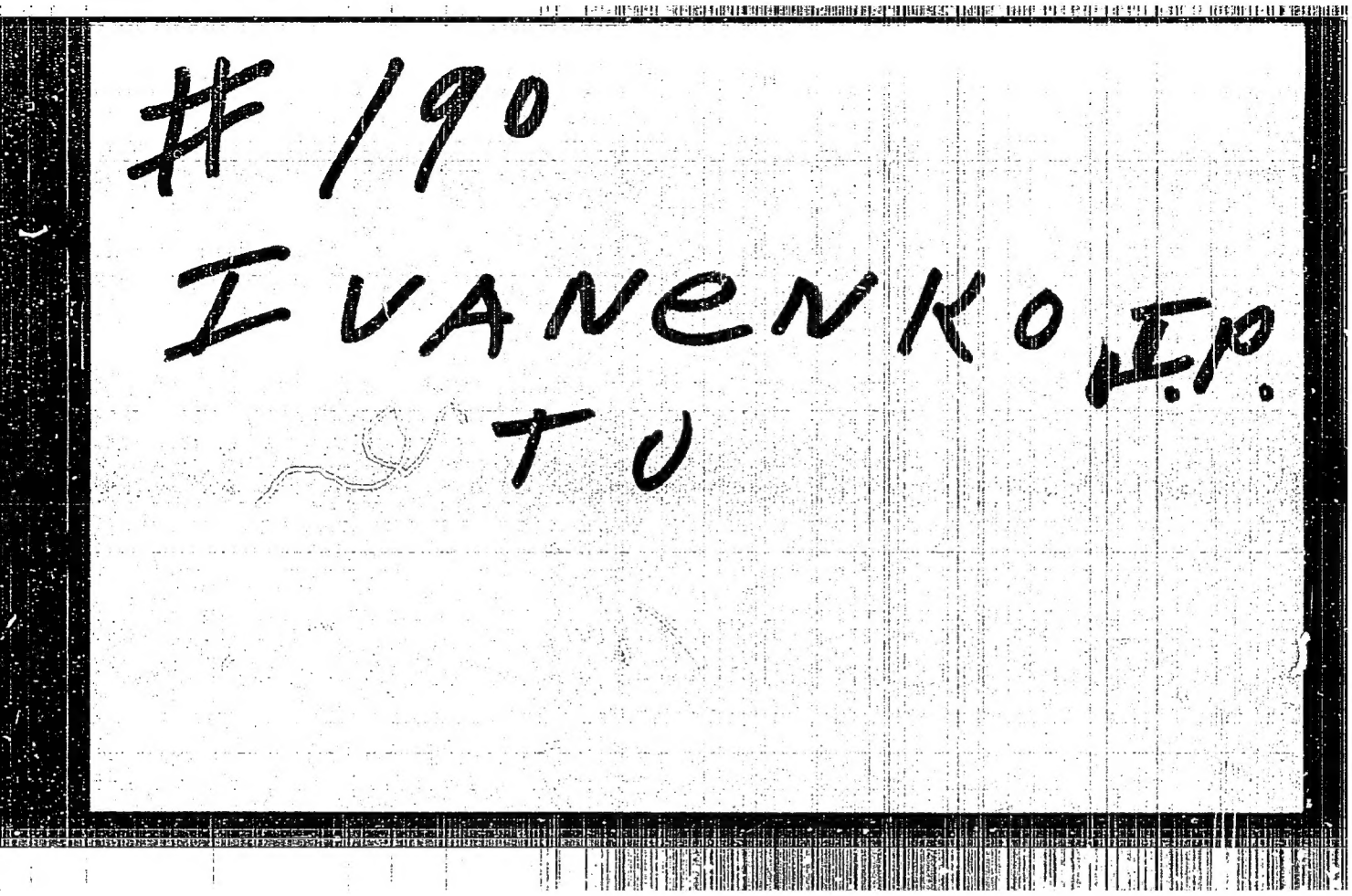
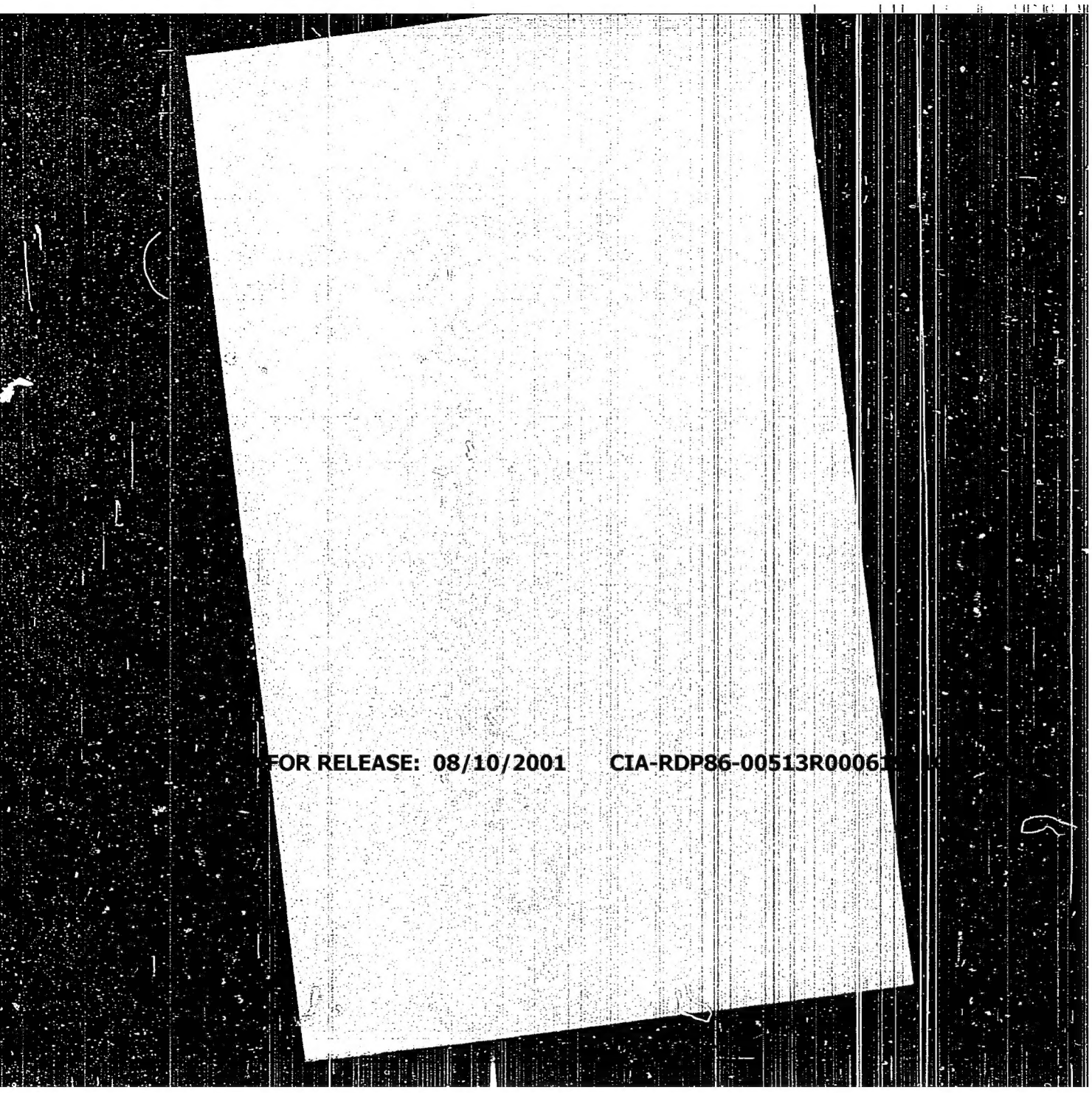






IVANENKO, I.P.

KHIZHNIAK, P.P.; IVANENKO, I.P.

[Safety measures in woodworking] Tekhnika bezopasnosti pri derevo-obrabotke. 2-e izd. Moskva, Profizdat, 1954, 62 p. (MLRA 8:2D)

YAKOVLEV, M.F.; VASIL'YEVA, V.A.; VIKHROV, P.P.; IVANENKO, I.P.; POGORELOV, G.I.; TROITSKIY, N.L.

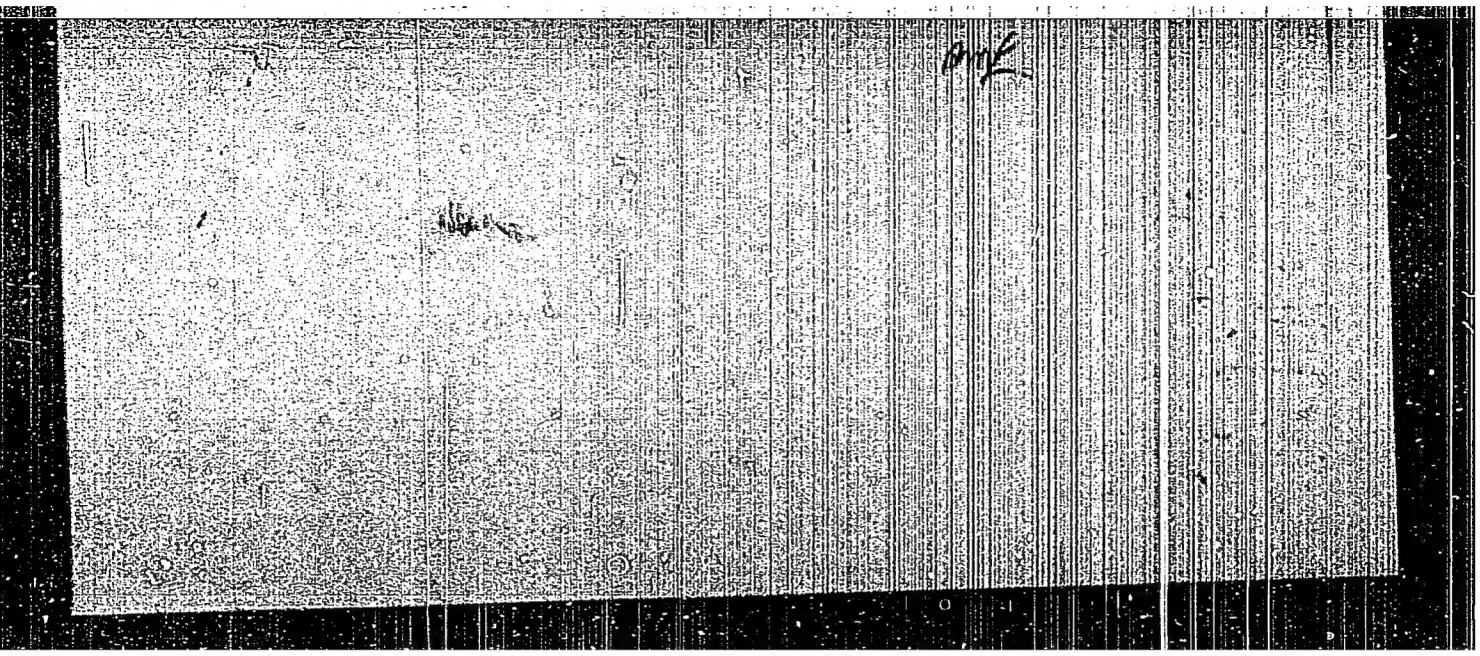
General inspection of the work organization level in factories. Tekst.prom. 20 no.6:51-53 Je '60. (MIRA 13:7)

1. Nachal'nik podotdela organizatsii truda Mosoblsovnarkhoza (for Yakovlev). 2. Tekhnicheskiye inspektora Moskovskogo otdeleniya soveta profsoyuzov pri obkome profsoyuza rabochikh tekstil'noy i legkoy promyshlennosti (for all except Yakovlev).
(Moscow Province—Textile factories)

IVANENKO, I. P.

IVANENKO, I. P. -- "The Method of Moments in Cascade Theory." Moscow Order of Lenin and Order of Labor Red Banner State U imeni M. V. Lomonosov. Moscow, 1955. (Dissertation for the Degree of Candidate of Physicomathematical Sciences.)

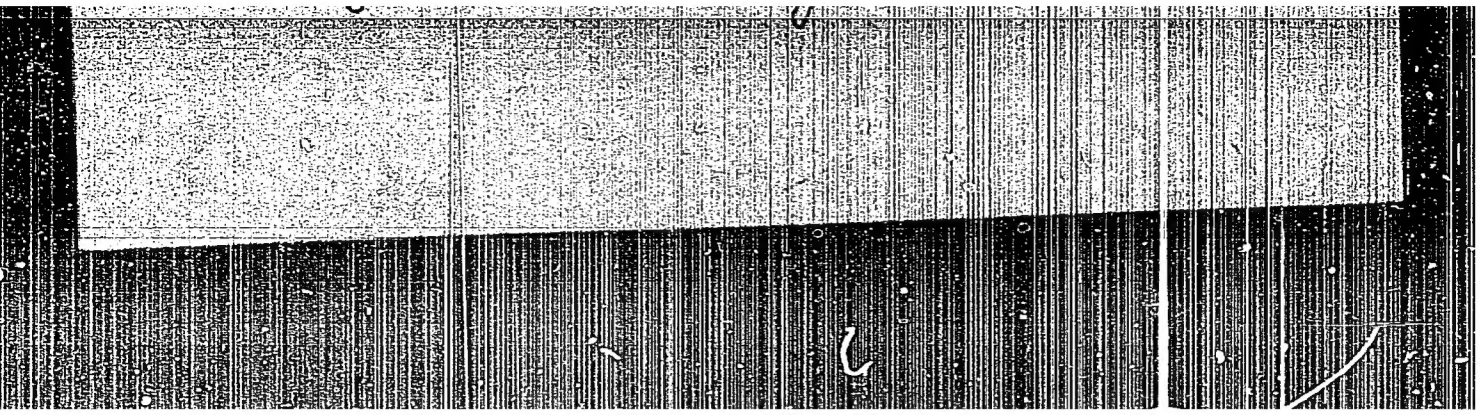
SO: Knizhnaya letopis', No. 4, Moscow, 1956



IVANENKO, I.P.

Electron and photon cascade curves in light and heavy elements.
Izv.AN SSSR Ser.fiz.19 no.6:624-628 N-D '55. (MIRA 9:4)

1.Moskovskiy gosudarstvennyy universitet imeni M.V.Lomonosova.
(Cosmic rays) (Nuclear physics)



APPROVED FOR RELEASE: 08/10/2001 CIA-RDP86-00513R000619010001-3"

Ivanenko, I. P.

C-3

USSR/Nuclear Physics - Elementary Particles

Abst Journal : Referat Zhur - Fiziki, No 12, 1956, 33911

Author : Ivanenko, I. P.

Institution : Moscow State University, Moscow, USSR

Title : Cascade Curves of Electrons and Photons for Lead

Original Periodical : Dokl. AN SSSR, 1956, 107, No 6, 819-822

Abstract : The 2 first moments t and t^2 of the depth t of the distribution functions of electrons $N_p(E_o, 0, t)$ in lead with energies greater than zero in a shower caused by a primary electron or photon of energy E_o are calculated. The moments are calculated with allowances for the dependence of the total adsorption coefficient of the photon on the energy and with allowance for the multiple Rutherford scattering of the electrons at primary-particle energies from 3 to 330 Mev. The resultant values of

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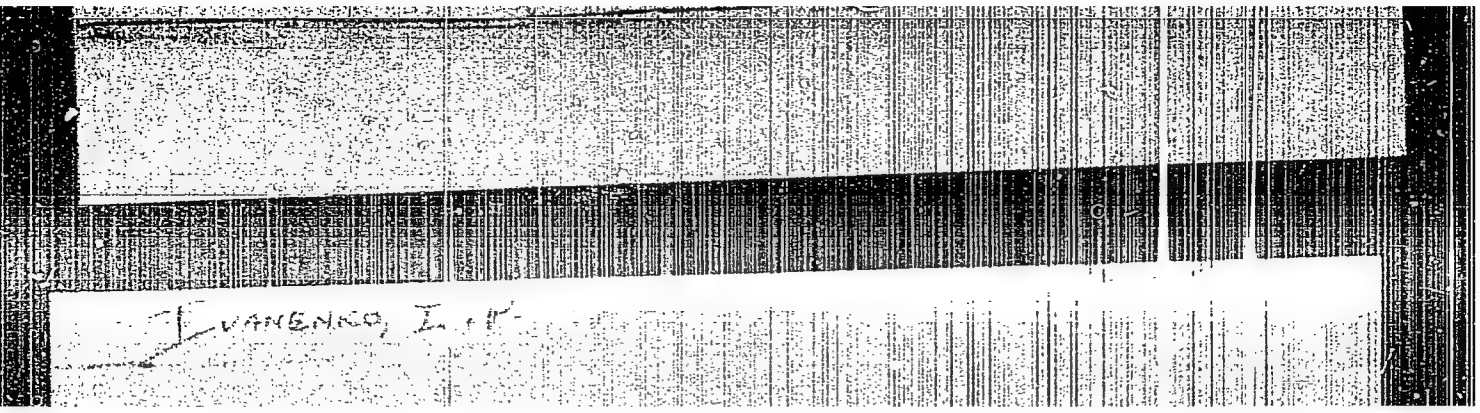
Abst Journal : Referat Zhur - Fizika, No 12, 1956, 33911

the moments were used to plot the cascade curves. The cascade curves were approximated by the author with the aid of a sum of Laguerre polynomials $L^{i}_{(n)}(x)$:

$$N(E_0, 0, t) = (\gamma t)^{i} e^{-\gamma t} \sum_{n=0}^{k} A_n L^{i}_{n}(\gamma t) .$$

The coefficients A_n , determined from the orthogonality conditions of the Laguerre polynomials, are simply related to the moments of the unknown function; γ was considered to be equal to the minimum value of the coefficient of absorption of the most penetrating portion of the radiation, namely the photons. Cascade curves are given for lead due to the primary electrons in the energy region from $3 \cdot 10^6$ to 10^{10} ev and from the primary photons with energies from 3 to 330 Mev.

Card 2/2



4034

ENERGY SPECTRUM OF CASCADE PHOTONS IN LIGHT SUBSTANCES. I. P. Ivanenko and M. A. M[illegible] ([illegible] State Univ.). Soviet Phys. JETP 5, 112-14(1957) Aug.

The energy spectrum of cascade photons in light substances was calculated using the system of polynomials orthogonal in the interval (0, ∞). The results of the cal-

PA - 2033

AUTHOR IVANENKO, I.P., MALKOV, M.A.

TITLE The Energy Spectrum of Cascade Photons in Light Substances.(Russian)

PERIODICAL Zhurnal Eksperimental'noi i Teoret.Fiziki, 1957, Vol 32, Nr 1, pp 150-151 (U.S.S.R.)

Received 3/1957 Reviewed 3/1957

ABSTRACT By the momentum method (pertinent works are cited) it was possible to furnish a nearly complete description of the one-dimensional development of electron-photon cascade showers in light as well as in heavy substances. The method is based on the computation (with the aid of recurrence formulae) of the momenta in the depth t from the function $N(E_c,E^o,t)$ of the distribution of the number of particles with an energy exceeding the value E in a shower which is produced by a primary particle with the energy E_o.

I.P.IVANENKO, Zhurn.Eksp.i Teoret.Fiz., Vol 32, Nr 2(in print), 1957, developed a method for the computation of the energy spectra of cascade electrons using a system of polynomials which are orthogonal (in the interval $0,\infty$). In the present work the energy spectrum of cascade photons in light substances is computed in a similar manner. The results of the computation of the number $\{N(E_o,E^o,t)\}$ P, Γ of the particles in the shower produced by a primary electron or photon in air are given for several values of E^o, E_o, and t in two tables.

The accuracy of the computation method employed here was examined by different works (cited here). Besides, the values of the approximated curves agree within a 10 o/o limit with the values computed by means of the exact formulae of the theory at $E_o/\beta \gg 1$. Here β denotes the critical

Card 1/2

AUTHOR IVANENKO I.P. PA - 2680

TITLE The equilibrium spectrum of electrons and photons with of scattering taken into account. (O ravnovesnom spektre elektronov i fotonov s uchetom rasseyaniya.- Russian)

PERIODICAL Zhurnal Eksperim. i Teoret. Fiziki 1957, Vol 32, Nr 2, pp 333-337 (USSR)

Received: 5/1957 Reviewed: 6/1957

ABSTRACT The present work supplies the exact solution of the equation of this equilibrium spectrum, i.e. an expression is found for the angular- and energy distribution of the particles in the maximum of a shower in heavy substances.

At first the basic equations of the cascade theory are written down in consideration of scattering:

$$\cos\vartheta(\partial P/\partial t) = L_1[P(E_0,t,E,\vartheta),\Gamma(E_0,t,E,\vartheta)] + (E_k^2/4E^2)\,\Delta_\vartheta P(E_0,t,E,\vartheta)$$

$$\cos\vartheta\,\partial\Gamma/\partial t = L_2[P(E_0,t,E,\vartheta),\Gamma(E_0,t,E,\vartheta)].$$

Here P and Γ denote the functions of the distribution of electrons and photons respectively over the depth t, the energy E and the angle ϑ in a shower which is caused by a primary particle with the energy E_0. L_1 and L_2 are integrodifferential operators which act upon the variable E and take into account the production of pairs by photons, radiation deceleration and ionization losses of the electrons. Δ_k denotes the LAPLACE operator and E_k = 21 applies. The auther assumes the following

CARD 1/2

ASSOCIATION: Moscow State University.

PRESENTED BY: -

SUBMITTED: 2. 12. 1955.

AVAILABLE: Library of Congress.

CARD 2/2

AUTHOR IVANENKO, I.P., PA - 2960

TITLE The Energy Spectrum of Avalanche Electrons in Lead.
(Energeticheskiy spectr lavinnykh electronov v svintse - Russian)

PERIODICAL Zhurnal Eksperim. Teoret. Fiziki, 1957, Vol 32, Nr 3, pp 491-497, (U.S.S.R.)

Received 6/1957 Reviewed 7/1957

ABSTRACT The method for the computation of the cascade curves suggested previously by the author can easily be generalized for the computation of the energy spectra of avalanche particles in heavy elements. The present paper furnishes recurrence formulae for the moments of the function of the depth distribution of particles with an energy higher than E^o in a shower which is caused by a primary particle with the energy E_o. These formulae are here given explicitly. The results of the computation of the moments $\bar{t}$ and $\bar{t^2}$ for lead, carried out by taking account of the dependence of the total absorption coefficient $\sigma(E)$ of the photons upon energy, and in consideration of RUTHERFORD'S scattering of the charged particles, are shown together in a table for some values of the energies E_o and E^o. The distribution functions computed here are shown in a diagram. In a given depth t_i behind the maximum of the avalache the energy spectrum of the avalache particles will be softer in light elements than in heavy elements. The author confirms this by further computations. From various curves given here the "equilibrium spectrum" integrated with respect to depth can be determined. It agrees with an accuracy of 1o/o with the expression obtained by TAMM, J. and BELENKY, S., J.Phys.USSR, Vol1, Nr ?, p 177 (1939) which speaks for the

Card 1/2

The Energy Spectrum of Avalache Electrons in Lead.

accuracy of numerical results. Thus, the cascade curves for lead found here do not differ by more than 5 to 10°/o from the exact curves. Also the formulae are written down for the case that a photon spectrum of the type $\Gamma(E_0,0,E,\vartheta) = \delta\gamma(E_0,E)\delta(\vartheta)$ falls on to the boundary of the material layer. (Here E_0 denotes the upper boundary of the spectrum). The results obtained are correctin the case of such tests in which the measuring device is surrounded on all sides by an absorber.
(4 ill., and 4 tables.)

ASSOCIATION Moscow State University.
PRESENTED BY
SUBMITTED 2.12.1955.
AVAILABLE Library of Congress.
Card 2/2

IVANENKO, I.P.

56-3-56/59

AUTHOR: Ivanenko, I.P.

TITLE: On the Function of the Angular Distribution of the Particles in the Maximum of a Cascade Shower (O funktsii uglovogo raspredeleniya chastits v maksimume kaskadnogo livnya) (Letter to the Editor)

PERIODICAL: Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol. 33, Nr 3 (9), pp. 825 - 827 (USSR)

ABSTRACT: S.Z. Belen'kiy (Lavinnyye protsessy v kosmicheskikh luchakh, Gostekhizdat, 1948) computed the function of the distribution of the particles over the energies and angles in the maximum of a cascade shower without assuming the smallness of the angle of deviation. Scattering, however, was looked upon as a multiple scattering. The latter, restriction does not exist in the case of the present paper. The equation for $P(E,\vartheta)$ integrated with respect to the depth of the development of the shower, which corresponds to this case, is written down here. Ionization losses are not taken into account here and therefore the computations discussed here hold for the energies $E > \beta$. The solution of this equation is set up in form of a series according to Legrendre polynominals. The further development of the computation is sketched out and the result

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56-3-56/59

On the Function of the Angular Distribution of the Particles in the Maximum of a Cascade Shower

obtained by approximation by taking into account the screening and the finite dimensions of the nucleus (i.e. the function of the energy- and angular distribution of the electrons) is written down. The functions φ_n occurring at the beginning of the development in series are specially written down. In conclusion also the expressions for $\cos \vartheta_N$ and $\cos^2 \vartheta_n$ are determined by means of the distribution functions derived here. There is 1 Slavic reference.

ASSOCIATION: Moscow State University
(Moskovskiy gosudarstvennyy universitet)

SUBMITTED: June 25, 1957

AVAILABLE: Library of Congress

Card 2/2

IVANENKO, I.P

AUTHOR: IVANENKO, I.P. 56-7-20/66

TITLE: The Energy Spectrum of Cascade Electrons in Light Substances. (Energeticheskiy spektr lavinnykh elektronov v legkikh veshchestvakh, Russian)

PERIODICAL: Zhurnal Eksperim. i Teoret. Fiziki, 1957, Vol 33, Nr 7, pp 135-138 (U.S.S.R.)

ABSTRACT: By means of the moment method the energy spectrum of shower electrons in light substances is calculated. The showers create either electrons or photons. For both cases the functions $\left\{ N_p (E_o, t, E) \right\}^p$ and $\left\{ N_p (E_o, t, E) \right\}^\Gamma$ are numerically tabulated, viz. for E_o from 0,6 - 15; E from 0,03 - 2; and t from 0,1 - 4,0. (With 2 Illustrations and 4 Slavic References).

ASSOCIATION: Moscow State University (Moskovskiy gosudarstvennyy universitet)

PRESENTED BY:

SUBMITTED: 15.12.1956

AVAILABLE: Library of Congress

Card 1/1

IVANENKO, I.P

PA - 3135

AUTHOR GUZHAVIN V.V., IVANENKO I.P.

TITLE On the Function of the Angular- And the Spatial Distribution of the Particles in the Maximum of a Cascade Shower.
(O funktsii uglovogo i prostranstvennogo raspredeleniye chastits v maksimume kaskadnogo livnya)

PERIODICAL Doklady Akademii Nauk SSSR, 1957, Vol 113, Nr 3, pp 533-536 (U.S.S.R.)
Received 6/1957 Reviewed 7/1957

ABSTRACT According to the opinion of the authors the method of moments is well suited for the solution of the problem mentioned above. The authors here suggest a simple method for the computation of the functions from the known moments, as mentioned in the title. These functions depend upon $\vec{r}$ and $\vec{\theta}$ only in the combination $x_\theta = E\theta/E_s (x_r = E_r/E_s)$, where E_s amounts to 21MeV.

The differential function of the angular distribution $P(E_0, E, \theta, t) = P_{prod}(E_0, E, T_s) P(s, x_\theta)$ remains finite at $\theta = 0$.
The authors approximate the function $P(1, x_\theta)$ by a sum of polynomials $P(1, x_\theta) = e^{-\alpha x_\theta} \sum_{n=0}^{k/4-1} a_n V_n(\alpha x_\theta)$. The explicit expressions of the polynomials $V_n(\alpha x)$ as well as the polynomials $V_n(y)$ which are orthogonal to them are explicitly given. Also the expressions for the coefficients a_n are easily determined by the corresponding moments of the function of spatial distribution. The results of the computation of the function $P(1, x_\theta)$ are given in a table. The method of approximation of the function suggested here furnishes fairly accurate values even at $k = 4$. In addition, also an approxi-

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IVANENKO, I. P.

20-6-10/48

AUTHORS: Guzhavin, V.V., Ivanenko, I.P.

TITLE: On the Function of the Spatial Distribution of Particles in an Electron-Photon Shower (O funktsii prostranstvennogo raspredeleniya chastits v elektronnofotonnom livne)

PERIODICAL: Doklady AN SSSR, 1957, Vol. 115, Nr 6, pp. 1089 - 1092 (USSR)

ABSTRACT: In the preparatory paper (Doklady AN SSSR, 1957, Vol. 113, Nr 3) a method for the computation of the angular distribution and the spatial distribution of the electrons in the maximum of a cascade shower was suggested. The present paper develops a method for the computation of a more general class of functions from their known moments. The authors here investigate the function $\Phi(r, s)$ which is dependent on the parameter s and a few other parameters. This function is defined in the interval $0 \leqslant r < \infty$ where for r - 0 it is valid $\Phi(r,s) = (1/r^{2-s})$ $\varphi(r, s)$. Moreover it is valid $\varphi(r, s) = \text{const} \neq 0$; $0 < s \leqslant 2$. The moments of the function $\Phi(r, s)$ are defined by the formula $\overline{r^n_\Phi}(s) = \int_0^\infty \Phi(r, s) r^n dr / \int_0^\infty \Phi(r, s) dr$ and they are assumed as known here. In all practically interesting cases it is

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or the polynominals.
In the authors' opinion this approximation method is suitable for many problems. The present paper applies this method for the computation of the functions of the spatial distribution of the particles in an electron-photon shower. The expressions for the polynominals and for the coefficients are given expli-

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On the Function of the Spatial Distribution of Particles in an Electron-Photon Shower

citly. The formulae here deduced also provide useful results, if for example only the first two results are used. There are 1 table and 8 references, 4 of which are Slavic.

ASSOCIATION : Moscow State University imeni M.V. Lomonosov (Moskovskiy gosudarstvennyy universitet im. M.V. Lomonosova)

PRESENTED: April 9, 1957, by D.V. Skobel'tsyn, Academician

SUBMITTED: April 2, 1957

AVAILABLE: Library of Congress

Card 3/3

SOV/56-34-3-33/55

AUTHORS: Guzhavin V. V., Ivanenko, I. P.

TITLE: On the Function of the Spatial Distribution of Photons in the Maximum of a Cascade Shower (O funktsii prostranstvennogo raspredelenniya fotonov v maksimume kaskadnogo livnya)

PERIODICAL: Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, 1958, Vol. 34, Nr 3, pp. 746 - 747 (USSR)

ABSTRACT: The authors computed the function of the spatial distribution of photons by the method of momenta. The fact that the function of the spatial distribution of the photons $N_\Gamma(x_r)$ with an energy greater than E with $x_r \longrightarrow 0$, is proportional to $(\ln x_r)/x_r$, is taken into consideration here. Here holds: $x_r = Er/E_s^r$ with $E_s = 21$ MeV. The authors approximate the function $x_r N_\Gamma(x_r)$ by means of the following sum of polynomials: $x_r N_\Gamma(x_r = Ei(-\alpha\sqrt{x_r}) \sum_{n=0}^{N} \alpha_n R_n(\alpha x_r)$.

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On the Function of the Spatial Distribution of Photons in the Maximum of a Cascade Shower

In this case, $R_n(\alpha x_r)$ denote the orthogonal polynomials in the interval $(0, \infty)$ with the function of weight $Ei(-\alpha\sqrt{x_r})$. Conditions for the calculation of these polynomials are given. Also the explicit analytical terms for some of such polynomials R_n are written down. Formulae for the coefficients occurring in these terms are given. The results of the computation of the function of spatial distribution of photons are illustrated in a diagram and compared with the results obtained by G. Moliere (Reference 2). The corresponding curves do not differ by more than 20 % up to approximately $x_r \sim 0.1$. With $x_r \sim 1$, these curves differ by approximately the double from each other, but here the curve of Moliere is already unreliable. The functions of spatial distribution of the photons calculated here (which take into account the first 3 momenta) do not differ by more than 10 % from the accurate curve. The first diagram also contains the function of spatial distribution of the electrons. Even with $x_r = 10^{-4}$, the function of photon is 3 times greater than the electron function. There are 2 figures and 3 references, 1 of which is Soviet.

SOV/56-34-3-33/55

On the Function of the Spatial Distribution of Photons in the Maximum of a Cascade Shower

ASSOCIATION: Moskovskiy gosudarstvennyy universitet
(Moscow State University)

SUBMITTED: November 6, 1957

Card 3/3

AUTHOR: Ivanenko, I. P. SOV/56-35-1-18/59

TITLE: On the Cascade Theory of Showers (K kaskadnoy teorii livney)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 1, pp 132 - 136 (USSR)

ABSTRACT: The authors of the papers mentioned in reference 1 investigated the distribution function of particles which were produced in a layer of matter during t and t + dt (with energies of between E and E+dE at the origin); they further investigated the equation for the average number of particles $\epsilon(P(E_0 E,t)$ irrespective of ionization losses. In the present paper a solution of the last-mentioned equation is given in consideration of ionization losses and of a comparison between the results obtained and those of the ordinary cascade theory (Ref 2). Otherwise, conditions are the same as those of reference 1. The following ansatz is made for a shower caused by a primary electron with the energy E_0:

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$$\varepsilon(P(E_0,E,t)) = 2\int_E^{E_0} \Gamma(E_0,E',t)W_p(E,E')dE',$$

$$\varepsilon(\Gamma(E_0,E,t)) = \int_E^{E_0} P(E_0,E',t)W_e(E'-E,E')dE', \text{ where } \Gamma$$

characterizes the distribution of photons. For the number of electrons produced in a layer between 0 and t with energies $>E$ (at the origin), an equation is written down and solved. The functions $\varepsilon(N_p(E_0,E,t))$ as well as $N_{ps}(E_0,E,t)$, where

$$N_{ps}(E_0,E,t) = \int_0^t N_p(E_0,E,\tau)d\tau, \text{ are in the following}$$

tabulated in detail both with and without taking ionization losses into account. In conclusion the author thanks T.V.Klopkova for his assistance in carrying out

computations. There are 2 tables and 3 references, 2 of which are Soviet.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet (Moscow State University)

SUBMITTED: February 4, 1958

AUTHORS: Volkonskaya, T. G., Ivanenko, I. P., Timofeyev, G. A. SOV/56-35-1-48/59

TITLE: On the Influence of the Multiple Scattering Effects on the Evolution of an Electron-Photon Shower of High Energy in Lead (O vliyanii effektov mnogokratnogo rasseyaniya na razvitiye elektronno-fotonnogo livnya bol'shoy energii v svintse)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol. 35, Nr 1, pp. 293 - 294 (USSR)

ABSTRACT: This paper describes the results of the calculations of the longitudinal evolution of 154 showers caused by a primary electron with $E = 10^{12}$eV for 2 t-units and of 40 showers caused by a primary electron and photon in lead for 4 t-units. The calculations were carried out by means of the electronic computer "Strela" according to the Monte-Carlo (Monte-Karlo) method. The cross sections of the bremsstrahlung and pair-production processes were taken from a paper by Migdal (Ref 4), but the authors took into account that the refraction index of the medium is

Card 1/3

On the Influence of the Multiple Scattering Effects on the Evolution of an Electron-Photon Shower of High Energy in Lead

SOV/56-35-1-48/59

different from 1. A diagram demonstrates the average energy spectra of the electrons for the depths which correspond to 0,5; 1,0; 1,5; and 4 t-units. According to this diagram, the energy spectrum is changed by multiple scattering: There are more high-energy particles and less low-energy particles($< 10^9$ eV) with respect to the usual spectrum. Finally, the authors make some comments on the fluctuations of the number of shower particles. There are 1 figure, 1 table, and 6 references, 5 of which are Soviet.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet (Moscow State University)

SUBMITTED: April 8, 1958

Card 2/3

SOV/56-35-5-29/56

24(5), 24(6)
AUTHORS: Ivanenko, I. P., Samosudov, B. Ye.

TITLE: Cascade Curves for Copper (Kaskadnyye krivyye dlya medi)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1958, Vol 35, Nr 5, pp 1265-1270 (USSR)

ABSTRACT: In experimental work connected with cosmic radiation, copper or iron ionization chambers are used, which are shielded by filters made from various materials. Sometimes, iron or copper is used also as filtering material, and it is therefore necessary to have sufficiently accurate cascade curves for these elements. (The values obtained for copper can be used also for iron.) Such curves were obtained for copper by the momenta method (Ref 1). When calculating the momenta of the electron distribution curve $\left\{N_p(E_o Q, t)\right\}^{p,\Gamma}$ by means of a recurrence formula (Ref 2), the authors also took the dependence of the total absorption coefficient of the photons $\sigma(E)$ on energy, and also the Rutherford (rezerfordovskoye) scattering of the avalanche of charged particles into account. It is further assumed that the electrons released by electrons or photons of the primary

Card 1/3

Cascade Curves for Copper

energy E_o have an energy in a shower depth t, which is greater than zero. (For $\sigma(E)$ compare the book by Heitler (Zaytler) (Ref 3), a translation of which was published in Moscow.) In the cascade theory depth is measured according to so-called "avalanche length units"; such a t-unit for copper amounts to 11.6 g/cm^2, the critical energy is $\beta = 16.6$ MeV. The results obtained by calculating the two first moments $\bar{t}(\varepsilon_o,0)$ and $t^2(\varepsilon_o,0)$ for the primary particle energy ε_o (ε is measured in β/q units, $q = 2.29$, β - the critical energy) are shown in a table. The cascade curves obtained are shown for a large number of ε_o-values (for a primary photon) in diagrams (Figs 1,2) and for primary electrons (Figs 3,4,5). Figure 5 compares the cascade curves calculated by the authors (according to momenta) with those obtained by using the formula developed by Belen'kiy and Maksimov (Ref 2) as well as with those calculated according to the formula by Ott (Ref 6). There are 3 groups of curves for ε_o = 140, 560 and 1400 (ε_o in β/q units). There are 5 figures,

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Cascade Curves for Copper SOV/56-35-5-29/56

1 table, and 7 references, 4 of which are Soviet.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet (Moscow State University)

SUBMITTED: June 2, 1958

Card 3/3

21(7)

AUTHOR: Ivanenko, I. P.

SOV/20-122-3-12/57

TITLE: On the Equilibrium Function of the Angular Distribution of the Particles in a Cascade Shower (O ravnovesnoy funktsii uglovogo raspredeleniya chastits v kaskadnom livne)

PERIODICAL: Doklady Akademii nauk SSSR, 1958, Vol 122, Nr 3, pp 367-370 (USSR)

ABSTRACT: In this paper, the formulae for the function of the angular distribution of the particles in the maximum of the shower are found in the approximation of multiple scattering. In these calculations, the ionization losses are taken into account.in the approximation of small and large angles with respect to the primary particle of infinite energy. The author finds the formulae for the unknown function also for the case of a shower generated by a particle of infinite energy. First, the equations for the function $P(E_o, E, \vartheta)$ with respect to energy and to the angles are given explicitly for the case of a primary electron of the energy E_o. This electron falls vertically upon the boundary of the substance layer

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SOV/20-122-3-12/57

On the Equilibrium Function of the Angular Distribution of the Particles in a Cascade Shower

at t = 0. A formula is then given for the corresponding distribution function of the photons. Calculations are discussed step by step. Finally, the found distribution functions in the approximations of great and small angles are explicitly given. The formulae deduced in this paper can be accurately applied only to the case $E_0 = \infty$ where E_0 denotes the energy of the primary electron. For finite values of E_0, the character of the distribution function is very different from that for $E_0 = \infty$. The results obtained by the computation of the function of the angular distribution are given in a diagram. There are 1 figure and 6 references, 2 of which are Soviet.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet im. M. V. Lomonosova (Moscow State University imeni M. V. Lomonosov)

PRESENTED: May 20, 1958, by D. V. Skobel'tsyn, Academician

SUBMITTED: May 17, 1958

Card 2/2

IVANENKO, I.P.

"CONCERNING THE TRIDIMENSIONAL ELECTRON-PHOTON AVALANCHE DEVELOPMENT"
I.P. Ivanenko, V.V. Guzhavin

The effect of the energy E_0 of the primary particle causing an avalanche, upon the form of the angular and spatial particle distribution function at small values of the argument has been considered. An approximate method of calculating these functions is proposed and the angular and spatial distribution functions are presented for different values of the parameter S, from 0.4 to 1.6, and the ratios E_0/E, from 10 to 10^6. In a number of specific cases, a detailed study is made of the behavior of distribution functions close to o, with a finite value for E_0.

report presented at the International Cosmic Ray Conference, Moscow, 6-11 July 1959

31539
S/627/60/002/000/022/027
D299/D304

3.2410 (2205, 2805, 1559)

AUTHORS: Volkonskaya, T. G., Ivanenko, I. P., and Timofeyev, G.A.

TITLE: Development of electron-photon showers of high energy in condensed media

SOURCE: International Conference on Cosmic Radiation. Moscow, 1959. Trudy. v. 2. Shirokiye atmosfernyye livni i kaskadnyye protsessy, 269-291

TEXT: In the computations, carried out by the Monte Carlo method, only pair creation, bremsstrahlung and ionization of the atoms of the medium were taken into account. The results are given of calculations concerning the development of approximately 300 showers in lead plates, generated by primary electrons of energy 10^{12} ev., and of approx. 400 showers generated in photographic plates by primary photons of similar energy. Complete data are given on electrons and photons of energies $E \geq 4 \cdot 10^{7}$ ev. (14 energy intervals) at depths up to 2 t-units. From the integral energy spectra of elec-

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Development of electron-photon ...

trons and photons in lead at various depth, it is evident that the spectra with multiple scattering vary: The number of particles of higher energies increases whereas that of lower energies decreases. It is noted that in the corresponding differential spectra, the difference between the ordinary and the spectra with multiple scattering is greater than in the integral spectra. A comparison of integral spectra of electrons and photons in photographic plates with corresponding spectra of ordinary cross-section, showed that the difference between these spectra is greater than in the case of lead. It is noted that the experimental error is rather high. The number distribution of showers is plotted in figures for various depths, together with the Poisson-, Furry- and normal distribution. These plots show that at great and medium depths, the distribution is asymmetrical and fluctuations of the order of $\pm$ 0.7 $\bar{N}$ (>E) are met in approximately 40% of the cases. Hence it is rather difficult to observe the effects under study for showers with $E_0 = 10^{12}$ ev. The results of computations of the number distribution functions are listed in 23 tables; the standard deviations for several of these functions are listed in 2 tables. There are 10 figures, 25

4

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21(0)

AUTHORS: Vernov, S. N., Gorchakov, Ye. V., Ivanenko, I. P., Khristiansen, G. B.

SOV/56-36-4-39/70

TITLE: On the Development of the Nuclear- Active Components in Extensive Atmospheric Showers (O razvitii yaderno-aktivnoy komponenty shirokikh atmosfernykh livney)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1959, Vol 36, Nr 4, pp 1233-1239 (USSR)

ABSTRACT: Already Guzhavin, Guzhavina and Zatsepin (Ref 1) calculated the height dependence of high-energy nuclear-active particles and the number of high-energy μ-mesons at sea level, as well as the height-dependence of the nuclear-active and of the soft component of extensive air showers. The elementary act was calculated according to Landau (Ref 2) and Vernov (Ref 3). For all energies the collision cross sections were calculated, and for the free path in air the value $\lambda_0 = 65 \div 70$ g/cm^2 was obtained. The results of calculations depend in a high degree on λ_0; however,

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λ_0 is at energies of $\approx 10^{10}$ ev not known from experiments. Therefore, the authors of this paper calculated different characteristics for the nuclear-active (n.a.) component of extensive air showers (e.a.sh.), in which λ_0 is determined by the type of the elementary act and the experimental range of the absorption of n.a. particles ($E \approx 10^{12}$ ev). By making simple assumptions concerning the nature of the elementary act the spectrum of the n.a. particles in e. a. sh. was computed, and likewise the ranges for the absorption of n.a. particles and the energy fluxes in the showers. Also the probability for the observation of one or two high-energy n.a. particles in a given altitude is estimated. The main aim of this paper was to find characteristics of the e. a. sh. for various parameters of the elementary act and λ_0, which are sensitive to the nature of interation.

It was found that besides the e.a.sh. characteristics, which depend only weakly on the nature of the elementary particle, there exist also such as are highly dependent. An exact experimental investigation of the latter may lead to important results concerning the elementary act.

On the Development of the Nuclear- Active Components in Extensive Atmospheric Showers SOV/56-36-4-39/70

There are 2 figures and 11 references, 9 of which are Soviet.

ASSOCIATION: Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta (Institute of Nuclear Physics of Moscow State University)

SUBMITTED: October 16, 1958

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21(1), 21(7)

AUTHORS: Guzhavin, V. V., Ivanenko, I. P. SOV/56-36-5-32/76

TITLE: On the Dependence of the Mean Angle of Scattering of Particles on Their Distance From the Shower Axis
(O zavisimosti srednego ugla razleta chastits ot ikh rasstoyaniya do osi v kaskadnom livne)

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki 1959, Vol 36, Nr 5, pp 1509-1512 (USSR)

ABSTRACT: The problem of the theoretical treatment of spatial cascade showers has hitherto not been solved. In the three-dimensional cascade theory of showers either a spatial particle distribution function is generally used with integration with respect to the angle variable or one uses an angular distribution function and integrates over the surface which is perpendicular to the shower axis. In connection with investigations of high-energy photon showers in photoemulsions as well as with detailed investigations of the soft component in the core of an extensive air shower, knowledge of the complete solid angle distribution function of particles appears to be of importance. This is a very complicated mathematical problem, which can be approached for the time being

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On the Dependence of the Mean Angle of Scattering of Particles on Their Distance From the Shower SOV/56-36-5-32/76

only by means of methods of approximation (momentum method, numerical computation by means of an electronic computer). The authors make a contribution towards dealing with this problem by calculating the average angle $\bar{\theta}_x(E,x)$ formed by the particles with the energy E with the shower axis at a distance x from the latter. Scattering is considered to be multiple and calculated in Landau's approximation (Ref 2). Further, approximation is confined to small angles (i.e. cos $\theta \to 1$, sin $\theta \to \theta$), and ionization losses are neglected. The results obtained by theoretical investigation are compared with the results obtained by measurements carried out by N. L. Grigorov and M. A. Kondrat'yeva. Agreement (see table) is good if it is taken into account that the $\bar{\theta}$ - values were measured whereas the projections $\bar{\theta}_x$ were calculated, that $\theta_{x\,exp} = \theta_{exp}/1.6$ holds, and that, besides, errors of measurement amounted to 20 - 30%. There are 1 figure, 1 table, and 5 references, 2 of which are Soviet.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet (Moscow State University)

SUBMITTED: November 24, 1958

Card 2/2

IVANENKO, I.P.

Theory of the passage of nuclear cascades through the atmosphere. Zhur.eksp.i teor.fiz. 37 no.4:1046-1049 O '59.
(MIRA 13:5)

1. Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.
(Cosmic rays)

21(8)

AUTHORS: Vernov, S. N., Corresponding Member, AS USSR, Grigorov, N. L., Ivanenko, I. P., Lebedinskiy, A. I., Murzin, V. S., Chudakov, A. Ye. SOV/20-124-5-17/62

TITLE: A Possible Mechanism of the Production of "Terrestrial Corpuscular Radiation" Under the Action of Cosmic Rays (Vozmozhnyy mekhanizm sozdaniya "zemnogo korpuskulyarnogo izlucheniya" pod deystviyem kosmicheskikh luchey)

PERIODICAL: Doklady Akademii nauk SSSR, 1959, Vol 124, Nr 5, pp 1022-1025 (USSR)

ABSTRACT: By "terrestrial corpuscular radiation" the authors mean the fluxes of particles moving in the terrestrial magnetic field along closed orbits. According to the authors' opinion, the following radiation production mechanism deserves the most attention: Under the action of cosmic radiation, the earth, like any other celestial body, becomes a neutron source. The neutrons traverse the magnetic field without being disturbed as uncharged particles and attain great distances from the earth. The charged particles originating from neutron decay move in the magnetic field along the lines of force. The particle in the course of time reaches the region of high geomagnetic

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latitudes, where fieldstrength increases considerably with increasing latitude. In this region the velocity vector of the particle will, as the particle approaches the earth, turn so long with respect to the vector $\vec{H}$, until at the latitude λ_{max} the angle between the velocity of the particle and the vector $\vec{H}$ becomes equal to 90°. At this point the particle returns and begins to move in the rear direction along the same magnetic line of force. If conditions are favourable, the decay products of the neutrons may perform 10^{8} and more oscillations between the northern and the southern turning point. Therefore, the intensity of the flux of these particles increases by the same amount. Experimental data indicate the existence of such a radiation. The present paper carries out a closer investigation in order to find out by what factors the intensity of these rays is determined. Calculation is followed step by step. The authors calculate the intensity of the "terrestrial

corpuscular radiation" for various heights and latitudes; the results obtained by these calculations are shown by a diagram. They lead to the following conclusions: Although the number of neutrons decaying in the earth is very small, they may cause intensive cosmic radiation. The experimentally determined intensity is by $\sim$ 100 times lower near the equator than calculated intensity. According to experimental data there is no terrestrial corpuscular radiation in geomagnetic latitudes above 40°, but in the present paper $j(\lambda = 40^{\circ}) \sim j(\lambda = 0^{\circ})$ is obtained. This means non-agreement by more than 10^5 times the amount. In order to reestablish agreement with the experiment, it is useful to assume an additional flux of particles from "magnetic traps", which are particularly strong in large latitudes. This may be due to the existence of electric fields. This assumption also appears to be confirmed by the data concerning the considerable increase of perturbations of the terrestrial magnetic field with increasing latitude. With increasing latitude, the interdictions imposed upon energy by Stoermer's theory are being disobeyed to an ever-increasing extent. The

mechanism discussed in the present paper must apply also in the neighborhood of astrophysical objects having a magnetic field. Therefore, the investigation of this radiation in the neighborhood of planets may be a means of observing weak magnetic fields. The authors thank D. V. Skobel'tsyn for his advice and M. S. Rabinovich for discussions. There are 2 figures and 7 Soviet references.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet im. M. V. Lomonosova (Moscow State University imeni M. V. Lomonosov)

SUBMITTED: November 21, 1958

ZHDANOV, G.B., glav. red.; IVANENKO, I.P., pom. glav. red.; GERASIMOVA, N.M., red. toma; NIKISHOV, A.I., pom. red. toma; ZATSEPIN, V.I., red.; KHRENOV, V.A., red.; DORMAN, L.I., red.; TULINOV, V.F., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.;

Proceedings of the Moscow Cosmic Ray Conference. July 6-11, 1959. Moscow. Vol.1. 1960. 333 p.
(No subject heading)

ZHDANOV, G.B., glav. red.; IVANENKO, I.P., pom. glav. red.; ZATSEPIN, V.I., red. toma; KHRENOV, V.A., pom. red. toma; GERASIMOVA, N.M., red.; NIKISHOV, A.I., red.; DORMAN, L.I., red.; TULINOV, V.F., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.

Proceedings of the Moscow Cosmic Ray Conference, July 6-11, 1959. Moscow. Vol.2. Extensive air showers and cascades process. 1960. 331 p.
(No subject heading)

ZHDANOV, G.B., glav. red.; IVANENKO, I.P., pom. glav. red.;
SYROVATSKIY, S.I., red. toma; GERASIMOVA, N.M., red.;
NIKISHOV, A.I., red.p ZATSEPIN, V.I., red.; KHRENOV, V.A.,
red.; DORMAN, L.I., red.; TULINOV, V.F., red.; FEDOROV,
V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.

Proceedings of the Moscow Cosmic Ray Conference, July 6-11, 1959. Moscow.
Vol.3. 1960. 253 p.
(No subject heading)

ZHDANOV, G.B., glav. red.; IVANENKO, I.P., pom. glav. red.; DORMAN, L.I., red. toma; TULINOV, V.F., pom. red. toma; GERASIMOVA, N.M., red.; NIKISHOV, A.I., red.; ZATSEPIN, V.I., red.; KHRENOV, V.A., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.

Proceedings of the Moscow Cosmic Ray Conference, July 6-11, 1959. Moscow. Vol.14. Variations of cosmic-ray intensity. 1960. 365 p.

(No subject heading)

ZHDANOV, G.B., glavnyy red.; IVANENKO, I.P., zam.glavnogo red.; SYROVATSKIY, S.I., otv.red.toma; KHRENOV, B.A., zam.red.toma; GERASIMOVA, N.M., red.; NIKISHOV, A.I., red.; ZATSEPIN, V.I., red.; DORMAN, L.I., red.; TULINOV, V.F., red.; FEDOROV, V.M.; VAVILOV, Yu.N., red.; ABRASIMOV, A.T., red.; FRADKIN, M.I., red.izd-va; BRUZGUL', V.V., tekhn.red.

[Radiation belts of the earth. Primary cosmic radiation and its properties and origin] Radiatsionnyi poias Zemli. Pervichnoe kosmicheskoe izluchenie, ego svoistva i proiskhozhdenie. Moskva, Izd-vo Akad.nauk SSSR, 1960. 258 p. (Trudy Mezhdunarodnoi konferentsii po kosmicheskim lucham, no.3)

(MIRA 14:2)

1. International Conference of Cosmic Radiation.
(Cosmic rays)

GERASIMOVA, N.M., otv.red.toma; NIKISHOV, A.I., zamestitel' red.toma; ZHDANOV, G.B., glavnyy red.; IVANENKO, I.P., zamestitel' glavnogo red.; ZATSEPIN, V.I., red.; KHRENOV, B.A., red.; DOBMAN, L.I., red.; TULINOV, V.F., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.; GUROV, K.P., red.izd-va; BRUZGUL', V.V., tekhn.red.

[Transactions of the International Conference on Cosmic Rays] Trudy Mezhdunarodnoi konferentsii po kosmicheskim lucham. Moskva, Izd-vo Akad.nauk SSSR. Vol.1. [Nuclear interactions at energies of 10^{11}-10^{14} ev.] IAdernye vzaimodeistviia pri energiiakh 10^{11}-10^{14} ev. 1960. 335 p. (MIRA 13:9)

1. Mezhdunarodnaya konferentsiya po kosmicheskim lucham. Moscow, 1959. (Nuclear reactions)

ZHDANOV, G.B., glavnyy red.; IVANENKO, I.P., zam.glavnogo red.; ZATSEPIN, V.I., otv.red.toma; KHRENOV, B.A., zam.red.toma; GERASIMOVA, N.M., red.; NIKISHOV, A.I., red.; DORMAN, L.I., red.; TULINOV, V.F., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.; GUROV, K.P., red.izd-va; BERKGAUT, V.G., red.izd-va; BRUZGUL', V.V., tekhn.red.

[Extensive air showers and cascade processes] Shirokie atmosfernye livni i kaskadnye protsessy. Moskva, Izd-vo Akad.nauk SSSR, 1960. 351 p. (Trudy mezhdunarodnoy konferentsii po kosmicheskim lucham, no.2). (MIRA 13:12)

1. International Conference of Cosmic Radiation.
(Cosmic rays)

ZHDANOV, G.B., glavnyy red.; IVANENKO, I.P., zam.glavnogo red.; DORMAN, L.I., otv.red.toma; TULINOV, V.F., zam. redaktora toma; GERASIMOVA, N.M., red.; NIKISHEV, A.I., red.; ZATSEPIN, V.I., red.; KHRENOV, B.A., red.; SYROVATSKIY, S.I., red.; FEDOROV, V.M., red.; VAVILOV, Yu.N., red.; ABROSIMOV, A.T., red.; GUS'KOV, G.G., red.izd-va; BRUZGUL', V.V., tekhn.red.

[Transactions of the International Conference on Cosmic Rays] Trudy Mezhdunarodnoi konferentsii po kosmicheskim lucham. Moskva, Izd-vo Akad.nauk SSSR. Vol.4. [Variations in the intensity of cosmic rays] Variatsii intensivnosti kosmicheskikh luchei. 1960. 362 p. (MIRA 13:10)

1. Mezhdunarodnaya konferentsiya po kosmicheskim lucham. Moscow, 1959. 2. Magnitnaya laboratoriya AN SSSR, Moskva (for Dorman).

(Cosmic rays)

23936
S/035/61/000/006/018/044
A001/A101

3,2420

AUTHORS: Vernov, S.N., Chudakov, A.Ye., Lebedinskiy, A.I., Ivanenko, I.P.

TITLE: Composition of terrestrial corpuscular radiation and possible mechanisms of its origination

PERIODICAL: Referativnyy zhurnal. Astronomiya i Geodeziya, no. 6, 1961, 33, abstract 6A287 ("Tr. Mezhdunar. konferentsii po kosmich. lucham, 1959, v. 3", Moscow, AN SSSR, 1960, 54-58)

TEXT: Assuming that the outer radiation belt consists of electrons with energy spectrum $N(>E) \sim E^{-\gamma}$, the value of γ was determined to be ~ 5 for energies from 20 to 100 kev. Extrapolation of this spectrum to the region of lower energies (3 - 10 kev) would result in density of energy of particles which would exceed the density of energy of the constraining magnetic field. Therefore, either the spectrum of low-energy electrons must have a maximum or γ should be small. A weakening of the Earth's magnetic field was observed in the seat of a maximum filled trap. A fraction of auroras can be explained by leakage of particles from the outer belt into the atmosphere. The source of replenishment of the outer zone is solar corpuscular fluxes. At their motion, recombination is possible which gives

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20649

S/029/60/000/05/21/024
B008/B017

3.2100
21.5300

AUTHOR: Ivanenko, I., Candidate of Physical and Mathematical Sciences

TITLE: Magnetic "Trap" on the Way Into the Universe

PERIODICAL: Tekhnika molodezhi, 1960, No. 5, pp. 35-36

TEXT: The author reports on the radiation belts around the earth which were detected by means of artificial earth satellites. It had been known for a long time that the earth is a huge magnet. The magnetic field of the earth is a peculiar trap for low-energy charged particles. Physicists working at the problem of a controlled thermonuclear reaction use this principle to keep the hot plasma in a limited volume. On launching earth satellites, currents of charged particles were observed which had been trapped by the magnetic field of the earth. The various radiations were recorded by means of special instruments designed by the Soviet scientists S.N. Vernov, Corresponding Member of the Akademiya nauk SSSR (Academy of Sciences USSR), A. Ye. Chudakov, Candidate of Physical and Mathematical Sciences, et al. The main element of these instruments is the gas discharge counter by means of which the number of charged particles

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can be determined. The so-called scintillation counter is used to determine their energy. Soviet earth satellites furnished the first information on the high intensity of charged particles at altitudes of 225-700 km above the northern latitudes. The same observations were made by American earth satellites at altitudes of over 1,000 km above the equatorial latitudes. Only the launching of the third Soviet earth satellite made it possible to detect two radiation zones around the earth. The measuring instruments indicated the boundaries of the internal radiation zone. On the basis of the analysis of data obtained from the instruments, S.N. Vernov and A. Ye. Chudakov succeeded in proving that the protons with energies of about 100 million electron volts predominate in the internal radiation zone. The two scientists also suggested a hypothesis which explains this result in the most plausible manner. The instruments of the third earth satellite also furnished important information on the outer radiation belt. It was found that its radiation consists of high-energy electrons (about 100,000 ev). The number of these electrons changes in the course of time. According to data furnished by the instruments, the radiation intensity of the internal radiation belt remained almost constant. Exact data on distribution, composition, and

Magnetic "Trap" on the Way Into the Universe

S/029/60/000/05/21/024
B008/B017

energy of particles of the outer radiation belt were obtained by means of the first two Soviet cosmic rockets. The scientists explain the formation of this belt with the periodic emission of particles from the sun. Apparently, a very small portion of particles emitted by the sun is caught by the trap where they remain. The detection of the two radiation belts is of great importance for the development of space travel. The investigation of such radiations may also serve as a means of detecting weak magnetic fields of other celestial bodies. On p. 1 the photograph of S. N. Vernov, Corresponding Member AS USSR, is shown. There are 5 figures.

Card 3/3

GUZHAVIN, V.V.; IVANENKO, I.P.

Effect of the initiating particle on the three dimensional development of a cascade shower. Zhur.eksp.i teor.fiz. 38 no.2:662-664 F '60. (MIRA 14:5)

1. Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.
(Cosmic rays) (Particles (Nuclear physics))

S/056/60/039/002/042/044
B006/B070

AUTHORS: Vernov, S. N., Ivanenko, I. P., Kulikov, G. V., Khristiansen, G. B.

TITLE: The Nature of the Particle Beams in the Core of an Extensive Air Shower

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, 1960, Vol. 39, No. 2(8), pp. 509 - 512

TEXT: In an earlier paper (Ref. 1) the authors communicated their investigations of a shower core by means of diffusion chamber. They found that narrow beams consisting of 4-15 particles appear, and the beam trajectories are collinear. These particle beams are, either, cores of electron-photon avalanches released from π^0-mesons, or groups of high-energy muons. Which of these alternatives is correct, is now investigated. In the present paper, the authors show that the latter is much more probable. The first assumption is discussed in detail, and the experiment and its results are analyzed from this stand-point. The observed number of particles in the beam can only be released by primary particles whose

energy $E_0 \geqslant 10^{12}$ ev. The energy spectrum of electrons and photons in the avalanche at a depth of 2t-units had the following form (N - number of particles released by particles with $E_0 = 10^{12}$ ev):

E	10^8	10^9	10^{10}	10^{11}
$N_{el}(>E)$	5.5	4.0	2.5	0.5
$N_{phot}(>E)$	10	8.0	4.0	0.8

For their experiments, the authors used a plate of lead glass (type ТФ-1 (TF-1)) with high lead content. This plate covered one half of the diffusion chamber. 850 hours of measurement were made in the open chamber and 440 hours in the closed one. The actual number of particles observed in the showers is much smaller than that which would be expected if the first assumption on the nature of the collinear beam were true. Experiments performed with diffusion chamber, arranged above two rows of ionization chambers, gave similar results. The second assumption, that the observed beam consists of μ-mesons, is then briefly discussed. For

S/053/60/072/001/005/005
B013/B060

AUTHORS: Dobrotin, N. A., Grigorov, N. L., Zatsepin, G. T., Ivanenko, I. P., Charakhch'yan, A. N., Chudakov, A. Ye.

TITLE: Sergey Nikolayevich Vernov (On His 50th Birthday)

PERIODICAL: Uspekhi fizicheskikh nauk, 1960, Vol. 72, No. 1, pp. 153 - 155

TEXT: Sergey Nikolayevich Vernov celebrated his 50th birthday on July 10, 1960. The beginning of his scientific activity coincided with the beginning of an intensive research on cosmic rays (1931-1932). By his first studies he built the foundation for the present-day methods of investigating cosmic rays inside and outside of the stratosphere by means of radio signals emitted by automatic devices. From the start, Vernov worked in close contact with Academician D. V. Skobel'tsyn. In 1939, he completed a series of studies on cosmic rays in the stratosphere, measured at various latitudes. Stratospheric measurements made by Vernov from 1946 to 1949 yielded particularly detailed information on the nature of primary radiation. Basing on rules found by experiments

to govern the absorption of the primary components in the atmosphere, Vernov reached an important conclusion concerning a strong interaction of the primary particles of cosmic radiation with matter. In 1949, S. N. Vernov headed an expedition of Soviet physicists to the equatorial latitudes in the Indian Ocean. Stratospheric investigations made in the course of that expedition yielded convincing evidence of the existence of the disputed, so-called east-west asymmetry and of the positive charge of particles of cosmic radiation. For his research of cosmic radiation in the stratosphere, Vernov was distinguished with the Stalin Prize of 1st Class in 1949. From 1947 to 1949, Vernov organized comprehensive studies of the interaction of high-energy protons with matter in the stratosphere. Collisions of protons with atomic nuclei were found to give rise to an electron-photon component of cosmic radiation. This allowed the assumption that rapidly decaying mesons giving rise to the formation of photons and electrons are produced in the course of such processes. This hypothesis was confirmed by the discovery of π^0-mesons. In 1949 and 1951, Vernov and collaborators obtained experimental data confirming the presence of nuclear cascade processes in 10^{10}-ev primary cosmic particles. Vernov supervised comprehensive research work on the

interaction of cosmic rays with matter and obtained an insight into the mechanism of the formation of secondary cosmic rays in the atmosphere. It became thus possible to describe this process quantitatively. On Vernov's initiative, elementary processes of the interaction of 10^{11} - 10^{13} ev particles with atomic nuclei are being studied from a stratoplane. Under his supervision, a first-class laboratory was established at Moskovskiy gosudarstvennyy universitet (Moscow State University) to serve for research work on interaction of ultrahigh-energy particles (10^{14} - 10^{16} ev) with matter. The USSR network of stations for the permanent recording of cosmic rays was established with his participation, and is now operating under the IGY program. In acknowledgment of his scientific achievements, Vernov was elected Corresponding Member of the Akademiya nauk SSSR (Academy of Sciences USSR) in 1953. He was awarded the Lenin Prize in 1960 for his discovery and research of the outer radiation belt of the earth. S. N. Vernov is the head of the NIIYaF MGU (Scientific Research Institute of Nuclear Physics of Moscow State University), and runs the special section of the fizicheskiy fakul'tet MGU (Department of Physics at the MGU). There are 1 figure and 37 Soviet references.

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34353

S/203/61/001/006/005/021
D055/D113

3,2420(1049,1395,1482)

AUTHORS: Ivanenko, I.P., and Shabanskiy, V.P.

TITLE: The acceleration of particles in the Earth's outer radiation belt

PERIODICAL: Geomagnetizm i aeronomiya, v. 1, no. 6, 1961, 888-896

TEXT: Conditions in the inner and outer radiation belts of the Earth are compared. The relative stability of the outer belt is stressed. Particles in the outer belt may be accelerated under the influence of hydrodynamic waves originating on the boundary between the geomagnetic field and interplanetary plasma. It is shown that fairly fast protons and electrons are lost by being carried by hydromagnetic waves into denser layers of the atmosphere. The energy density of electrons with an energy of several tens of kev is either one order (according to a later estimate) or three orders (according to Van Allen) higher than the energy of the cold component, while the energy density of electrons with more than 200 kev is 1÷2 orders higher. Whatever the estimate, the Debye radius of the energy component is con-

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siderably smaller than the outer zone ($L \sim 3 \cdot 10^9$ cm). Therefore, the energy component assumes the form of a plasma and all its properties; one should not proceed from the assumption that the separate particles move in a geomagnetic field in questions concerning the potential acceleration of particles, their injection from solar flows, zonal instability, etc. There is no attachment between the Earth's nucleus and the force lines of the outer field because there is a neutral layer of atmosphere between the Earth and the ionosphere. Therefore, only the latter can have a stabilizing influence. But the energy of the particles of the radiation field contained in the neighboring tubes of force, which become considerably narrower towards the ionosphere, may be sufficient for slow displacement of the mass of the ionosphere during convection of these tubes. This may be one cause of ionospheric winds. It follows that, besides ionization losses and the exit of particles through magnetic plugs, particles can also escape from a geomagnetic trap by means of the relative convective instability of the system and the exit of tubes of force with the energy component of the plasma on the outside. Particles should accelerate endlessly, because the depth at which they enter the atmosphere and disintegrate is determined by the point of

reflection in the magnetic field and depends on the angle between the direction of the particle and the field. Therefore, there must be some mechanism which limits acceleration from above (1) scattering on Alfven waves, whereby the angle between the direction of the particle and the force line alters; (2) exit of particles from the geomagnetic field during ionization of the tubes of force; (3) removal of energy particles by shock waves into denser layers of the atmosphere. When an energy particle passes through the front of a perpendicular shock wave in plasma with a magnetic field, the particle accelerates much more quickly than heat particles. This occurs if the Larmor radius of the particle is much greater than the width of the front. The particle becomes attached to the front for a certain time and moves with it. Thus, particles whose Larmor radius is greater than the width of the front, will be carried away by waves reaching the denser layers of the atmosphere from the periphery of the geomagnetic field along a radius towards the center of the Earth. There are 1 table and 13 references: 8 Soviet and 5 non-Soviet references. The four most recent English-language references are: J.A. Van Allen, C.E. McIlwain, J.H. Ludwig - J. Geophys. Res., 1959, 64, no. 3, 271; W.H. Hess - J. Geophys. Res., 1960, 65, no. 10, 3107; P. Rothwell, C.E. McIlwain - J.Geophys. Res., 1960,

S/203/61/001/006/005/021
D055/D113

The acceleration ...

65, no. 3, 799, R. L. Arnoldi, R.A. Hoffman , J.R. Winckler - J. Geophys. Res., 1960, 65, no. 5, 1361.

ASSOCIATION: Moskovskiy gosudarstvennyy universitet im M.V.Lomonosova. Institut yadernoy fiziki (Moscow State University imeni M.V. Lomonosov. Institute of Nuclear Physics)

SUBMITTED: October 19, 1961

Card 4/4

25191
S/056/61/040/006/012/031
B111/B201

24.6700

AUTHORS: Guzhavin, V. V., Ivanenko, I. P.

TITLE: Angular distribution function of particles in a shower released by a primary particle of a given energy

PERIODICAL: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 40, no. 6, 1961, 1682-1694

TEXT: The authors wanted to derive exact expressions for the angular distribution function in a number of special cases. The basic equations of cascade theory read, for small angular deviations,

$$\begin{aligned} \partial P(E_0, E, t, \vartheta)/\partial t &= L_1 [P(E_0, E, t, \vartheta), \\ \Gamma(E_0, E, t, \vartheta)] &+ (E_M^2/4E^2)\,\Delta_\vartheta P(E_0, E, t, \vartheta), \\ \partial\Gamma(E_0, E, t, \vartheta)/\partial t &= L_2 [P(E_0, E, t, \vartheta); \Gamma(E_0, E, t, \vartheta)]. \end{aligned} \quad (1)$$

(1),

where $P(E_0,E,t,\vartheta)$ and $\Gamma(E_0, E,t,\vartheta)$ are the desired distribution functions for electrons and photons, t is the penetration depth, L_1 and L_2 are

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integral operators which take account of bremsstrahlung and pair formation, $E_k = E_s (I_{\text{pair form}} / I_{\text{bremsstr}})^{1/2}$, $E_s = 21$ Mev. The boundary conditions for a primary, perpendicularly incident electron or photon read

$$P(E_0, E, 0, 0) = \delta(E_0 - E)\,\delta(0), \quad \Gamma(E_0, E, 0, 0) = 0 \qquad (1a)$$

and

$$P(E_0, E, 0, 0) = 0, \quad \Gamma(E_0, E, 0, 0) = \delta(E_0 - E)\,\delta(0) \qquad (1b)$$

respectively. By way of numerous integral transformations, transformations and substitutions, the distribution function of particles on the incidence of an electron is finally obtained. When neglecting the dependence of s on θ, the result of S. Z. Belen'kiy (Lavinnyye protsessy v kosmicheskikh luchakh, Gostekhizdat, 1948 (Shower processes in cosmic radiation). S. Z. Belen'kiy, I. P. Ivanenko, UFN, 69, 591, 1959) is obtained. The authors also calculated $N_p(E_0, E, t, \theta)^P$ and $P(E_0, E, t, \theta)^P$ taking account of the dependence of s on θ. The formulas are rather complicated, and are specialized for $z \ll 1$ and $z \gg 1$. The difference between the general and the two special formulas is estimated, and it is stated that the effect of a finite E_0 on the form of the distribution function is fairly important.

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namely, the more important, the smaller E_0/E and z are. For the distribution function in case of an incident photon,

$$\{N_\Gamma(E_0, E, t, \vartheta)\}^P = \{N_\Gamma(E_0, E, t)\}^P \frac{sF_1(s, z)}{2\pi\vartheta^2 2^{(s-2)/2}\Gamma(s/2)}, \quad (8)$$

is derived with

$$F_1(s, z) = z^s \int_z^\infty dz' z'^{-s/2} K_{(s-2)/2}(z'). \quad (II).$$

The angular distribution function of electrons normalized to unity and integrated over the energy is found to coincide with the angular distribution function of photons differentiated with respect to E. In addition, formulas are given for the distribution functions of particles in a shower released by a photon, generally at first, and then specialized for $z \gg 1$ and $z \ll 1$. Likewise, the distribution function of photons in a shower released by a photon is given. It is further stated that the distribution functions of electrons normalized to unity do not depend upon the nature of incident particles. As regards photons, this state-

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IVANENKO, I. P., TVERSKOY, B. A. and SHABANSKIY, V. P.

"On the radiation belt theory"

report to be submitted for the 13th Intl. Astronautical Congress, IAF, Varna, Bulgaria, 23-29 Sep 1962.

GUZHAVIN, V.V.; IVANENKO, I.P.

Effect of the nature of a primary particle of an electron-photon cascade shower on the form of the angular and spatial distribution functions. Vest. Mosk. un. Ser. 3:Fiz., astron. 18 no.5:3-7 S-O '63. (MIRA 16:10)

1. Nauchno-issledovatel'skiy institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.

GUZHAVIN, V.V.; IVANENKO, I.P.

Use of the method of moments in solving a three-dimensional angular problem in electromagnetic cascade theory. Izv. AN SSSR. Ser. fiz. 28 no.11:1841-1846 N '64. (MIRA 17:12)

1. Nauchno-issledovatel'skiy institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.

ASTAF'YEV, V.A.; IVANENKO, I.P.

Inverse problem in cascade theory. Izv. AN SSSR. Ser. fiz. 28 no.11:1847-1853 N '64. (MIRA 17:12)

1. Nauchno-issledovatel'skiy institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta.

L 4526-66 EWT(m)/FCC/T IJP(c)

ACC NR: AP5024640 SOURCE CODE: UR/0048/65/029/009/1709/1713

AUTHOR: Astaf'yev, V.A.; Ivanenko, I.P.

ORG: Scientific Research Institute of Nuclear Physics, Moscow State University im. M.V.Lomonosov (Nauchno-issledovatel'skiy institut yadernoy fiziki Moskovskogo gosudarstvennogo)

TITLE: Concerning the stability of the solution of the inverse problem in cascade theory /Report, All-Union Conference on Cosmic Ray Physics held at Apatity 24-31 August 1964/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v.29, no. 9, 1965, 1709-1713

TOPIC TAGS: extensive air shower, mathematic method, distribution function, inverse problem,

ABSTRACT: The authors have recently discussed the inverse problem of cascade theory (Izv. AN SSSR Ser. fiz., 1847, 1964) and have developed methods for calculating the moments of the probability distributions for the elementary processes involved in a cascade from observed characteristics of the cascade. In the present paper they discuss the stability of these methods, using as an example the simple Furry cascade (W. H.Furry, Phys. Rev., 52, 569, 1937), by calculating the errors in evaluating the moments that arise from small errors in determining the cascade spectrum. The effects

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ACC NR: AP5024640

on the different moments of different kinds of experimental error are discussed at some length. It is concluded that the method shows promise but that much work remains to be done before the solution of the inverse cascade problem can be used to derive reliable information concerning the characteristics of the elementary interaction event from experimental data on cosmic ray showers. Orig. art. has: 13 formulas and 3 figures.

SUB CODE: NP.,MA SUBM DATE: 00/- ORIG REF: 001/ OTH REF: 001

Card 2/2

L 452/-66 EWT(m)/EWP/T IJP(c)

ACC NR: AP5024641 SOURCE CODE: UR/0048/65/029/009/1714/1718

AUTHOR: Bakhtadze, A.K.; Guzhavin, V.V.; Ivanenko, I.P.

ORG: Scientific Research Institute of Nuclear Physics, Moscow State University im. M.V.Lomonosov (Nauchno-issledovatel'skiy institut yadernoy fiziki Moskovskogo gosudarstvennogo)

TITLE: On taking ionization losses into account in electromagnetic cascade theory /Report, All-Union Conference on Cosmic Ray Physics held at Apatity 24-31 August 1964/

SOURCE: AN SSSR. Izvestiya. Seriya fizicheskaya, v. 29, no. 9, 1965, 1714-1718

TOPIC TAGS: secondary cosmic ray, cosmic ray shower, electron, photon, mathematic method

ABSTRACT: The authors present without detailed proof differential operators which approximate under certain conditions the integral operator of electron-photon cascade theory. Such operators are presented for the four cases in which the cross sections are those of Bethe and Heitler with complete screening or with correct screening and ionization losses either included or neglected; such an operator is also presented for the case of completely screened Bethe-Heitler cross sections but with the electron angular distribution taken into account. The solutions of the cascade problem obtained with the aid of these operators are discussed. The authors have also solved

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ACC NR: AP5024641

the one-dimensional cascade equations with the cross sections of M.L.Ter-Mikaelyan (Dokl. AN SSSR, 94, 1033, 1954; Izv. AN SSSR. Ser. fiz., 19, 657, 1955), which take account of polarization of the medium, and with the cross sections of A.B.Migdal (Dokl. AN SSSR, 96, 49, 1954; Zh. eksperim. i teor. fiz., 32, 633, 1957), which are valid at very high energies. The use of the Ter-Mikaelyan cross sections removes the low energy logarithmic divergence of cascade theory. The solutions of the very high energy cascade equations, using the Migdal cross sections at energies of 10^{18}-10^{20} eV, differ from those of the cascade equations valid at lower energies mainly in scale: the cascade unit is replaced by a length proportional to the square root of the primary energy. Orig. art. has: 20 formulas and 2 figures.

SUB CODE: NP/ SUBM DATE: 00/ ORIG REF: 005/ OTH REF: 003

Card 2/2

L 09416-67 EWT(m) IJP(c)
ACC NR: AP6031661 SOURCE CODE: UR/0367/66/004/001/0161/0168

AUTHOR: Bakhtadze, A. K.; Ivanenko, I. P.

ORG: Institute of Nuclear Physics of the Moscow State University (Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta)

TITLE: Influence of polarization of a medium on the development and energy characteristics of electron-proton showers

SOURCE: Yadernaya fizika, v. 4, no. 1, 1966, 161-168

TOPIC TAGS: cosmic ray shower, proton interaction, electron interaction, pair production, spectral energy distribution

ABSTRACT: The authors develop a one-dimensional cascade theory of shower production in a medium, with and without allowance for the ionization losses, in the case of total screening (for media with small and medium Z). The Bethe-Heitler expression (Proc. Roy. Soc. v. 146, 83, 1934) is used for the probability of pair production in medium in the case of total screening. The general equations of the one-dimensional theory are derived and solved by a procedure similar to that used by S. Z. Belen'kiy (UFN v. 69, 591, 1959 and earlier). The energy spectra of the particle number in the shower and the dependence of the particle number on the depth are determined from these equations and the results are compared with other published data. An advantage

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L 09416-67
ACC NR: AP6031661 C

of the method in ... and the equilibrium spectra remain finite when account is taken of the polarizati... and the Bethe-Heitler cross sections, which lead to singularities. Orig. art. has: 2 figures, 13 formulas, and 4 tables.

SUB CODE: 20/ SUBM DATE: 22Apr65/ ORIG REF: 005/ OTH REF: 001

Card 2/2

ACC NR: AP7008885 SOURCE CODE: UR/0367/66/004/004/0807/0811

AUTHOR: Ivanenko, I. P.; Samosudov, B. Ye.

ORG: Nuclear Physics Institute, Moscow State University (Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta)

TITLE: Electron and photon equilibrium spectra with polarization of the medium and multiple scattering taken into account

SOURCE: Yadernaya fizika, v. 4, no. 4, 1966, 807-811

TOPIC TAGS: electron spectrum, particle scattering, photon

SUB CODE: 20

ABSTRACT: Expressions are obtained for electron and photon equilibrium spectra, in the B-approximation of the cascade theory, taking the polarization of the medium into account. Expressions are obtained for the equilibrium spectra, taking scattering into account for showers produced by particles with given finite energy E_0. Orig. art. has: 16 formulas and 1 table. [Based on authors' Eng. abst.] [JPRS: 39,658]

Card 1/1 UDC: none

ACC NR: AP6037077 SOURCE CODE: UR/0056/66/051/005/1483/1491

AUTHOR: Vaskin, A. I.; Guzhavin, V. V.; Ivanenko, I. P.

ORG: Institute of Nuclear Physics, Moscow State University (Institut yadernoy fiziki Moskovskogo gosudarstvennogo universiteta)

TITLE: New method of solving the equations of cascade theory

SOURCE: Zhurnal eksperimental'noy i teoreticheskoy fiziki, v. 51, no. 5, 1966, 1483-1491

TOPIC TAGS: cascade, bremsstrahlung, electromagnetic interaction, approximate solution, particle distribution

ABSTRACT: This is an elaboration of an earlier communication (Izv. AN SSSR ser. fiz. v. 29, 1714, 1965), where a new method of solving the equations of electromagnetic cascade theory was outlined. The method is based on replacing the integral operator describing electron bremsstrahlung and pair production by photons by a simple approximate differential operator. In many cases this substitution greatly simplifies the integral differential equations of the cascade theory, reducing them to linear differential equations. An analysis of the solutions of the approximate differential equations shows that these solutions are in many important cases more accurate than the non-approximate solutions of the initial exact equations. By way of an example, the method was applied to the solution of the equations of one-dimensional cascade theory in the two approximation (A and B) defined by S. Z. Belen'kiy (Lavinnyye

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ACC NR: AP6037077

protsessy v kosmicheskikh luchakh [Cascade Processes in Cosmic Rays], Gostekhizdat, 1948). The method is applied to calculations with and without account of ionization losses. Among the problems that can be simplified by this method are the construction of a theory that accounts for the energy dependence of the absorption coefficient of the photons, and the determination of angular and spatial distributions of the particles. Orig. art. has: 5 figures, 24 formulas, and 1 table.

SUB CODE: 20/ SUBM DATE: 20May66/ ORIG REF: 003/ OTH REF: 002

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IVANENKO, I.S., gornyy inzhener

Classification of combined mining systems. Ugol' U. no.6: 5-6 Je '61. (MIRA 14:7)
(Donets Basin--Coal mines and mining)

IVANENKO, I.S., inzh.

Studying the relationship between underground transportation and stoping operations in cases of advancing and retreating mining methods. Ugol'.prom. no.4:14-18 Jl-Ag '62. (MIRA 15:8)
(Mining engineering)

PETTSEL', V.A.; POLUBNEV, V.F.; VASIL'YEVA, L.L.; KULIKOVA, R.Ye.; IVANENKO, I.S.; SUGLOBOV, S.I.; BUD'KO, V.A.; GREBEN'KOV, M.V.

Experience in the prevention of chronic gastritis. Voen. med. zhur. no.10:61-63 O '65. (MIRA 18:11)

IVANENKO, I.Ye., dotsent.

Conditions for the advantageousness of supporting workings by reinforced concrete struts. Nauch. trudy NPI 32:9-17 '55. (MLRA 10:2)

(Mine timbering)

IVANENKO, I.Ye., dots.

Strength of rigid, reinforced concrete supports constructed by the Chistyakova plant. Ugol' 34 no.3:21-22 Mr '59. (MIRA 12:5)

(Mine timbering)
(Reinforced concrete construction)

IVANENKO, I.Ye., dotsent

Determining the stength of 28-day-old concret from its strength on the 7th day. Trudy NPI 74:19-26 (MIRA 14:3)

1. Kafedra razrabotki plastovykh mestorozhdeniy Novocherkasskogo politekhnicheskogo instituta.
(Concrete--Testing)

IVANENKO, I.Ye.

Criterion of advantageousness of selecting the kind of supports of major incline depending on the cost of contruction and maintenance. Trudy NPI 101:45-60 '60. (MIRA 15:5)
(Mine timbering—Costs)

IVANENKO, I.Ye.

Bearing capacity of rigid reinforced concrete supports of some factories of the Donets Basin. Trudy NPI 101:61-79 '60.
(MIRA 15:5)

(Donets Basin--Mine timbering)
(Donets Basin--Reinforced concrete construction)

IVANENKO, I.Ye.

Types of support elements made of rigid reinforced concrete struts. Trudy NPI 140:53-60 '63.

Studying the durability of timbering made of treated pine timbering. Ibid.:79-87 (MIRA 17:9)

IVANENKO, I. Ye., dotsent

Effect of antiseptizing mine supports made of pine on their strength. Izv. vys. ucheb. zav.; gor. zhur. no.8:38-43 '64
(MIRA 18:1)

1. Novocherkasskiy politekhnicheskiy institut. Rekomendovana kafedroy razrabotki plastovykh mestorozhdeniy, stroitel'stva i rekonstruktsii gornykh vyrabotok.

DENISOV, A.K., kandidat sel'skokhozyaystvennykh nauk; IVANENKO, K.S., redaktor; ARNOL'DOVA, K.S., redaktor; AGAPOV, F.F., tekhnicheskiy redaktor.

[Oak forests of forest zone bottom lands] Poimennye dubravy lesnoi zony. Moskva, Goslesbumizdat, 1954. 82 p. [Microfilm] (MLRA 7:11)
(Volga Valley--Forests and forestry)

MUN, N.P.; BORSHCHEVA, L.I.; IVANENKO, L.J.

Pathogenesis of experimental fatty degeneration of the liver.
Akt.vop.pat.pech. no.3:189-196 '65.
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BIRICH, T.B., prof.; KANTOR, D.V., dotsent; IVANENKO, L.M., ordinator; ZHMIYEVSKAYA, N.Ye., ordinator

Eye injuries in Minsk industrial establishments and measures for preventing them. Zdrav. Belor. 4 no.2:47-48 F '58. (MIRA 13:8)
(MINSK--INDUSTRIAL HYGIENE)
(EYE--WOUNDS AND INJURIES)